The Sudbury Neutrino Observatory ^{24}Na Calibration Source

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The energy spectrum of solar neutrinos resulting from ^{8}B β-decay will be measured in the SNO detector. The measurement will be indirect, as the neutrinos must interact with deuterium via a weak charged current, shown below:

$$\nu_e + d \rightarrow p + p + e^- \qquad (1)$$

The e$^-$ will receive most of the neutrino energy, less the 1.44 MeV threshold for the reaction. Detector calibration then requires measuring its response to electrons with energies below the 15 MeV ^{8}B β-decay endpoint.

Extreme measures and great care has been taken to minimize radioactive backgrounds in SNO. Nevertheless, due to the size of the detector, there will be a background due to Uranium and Thorium which greatly exceeds the solar neutrino detection rate for energies below about 5 MeV. Calibration beneath this background "wall" requires a source which triggers SNO. A suitable source has been developed which uses the β-decay of ^{24}Na inside a NaI(Tl) γ-ray detector. Two γ-rays (2.74 and 1.37 MeV) are in prompt coincidence with the β. The SNO response to the individual γ-rays may be determined by cuts on the NaI energy spectrum.

A trial irradiation was performed in December with a 3"×3" NaI detector at the Steacie Institute for Molecular Science, Chalk River Laboratories, Canada. Thermal neutron activation was performed on the NaI crystal to produce ^{24}Na. Thermal neutrons are required to avoid producing ^{24}Na by fast neutron (n,p) reactions on aluminum in the detector casing or other components which would not provide a tagged signal.

The halflife of ^{24}Na (15.5 hours) combined with the SNO maximum data acquisition rate impose a maximum useful lifetime of approximately 60 hours on the source. It is important that the level of activation be well controlled. The ^{24}Na activity produced during the trial was determined and the configuration of the reactor and neutron beam line were recorded. The configuration will be used again to allow an activation to a predetermined level when SNO calibrations are to be performed.

A stainless steel housing was designed and fabricated for this calibration source to protect the D_2O from contamination (Figure 1). The housing was designed to conform to the NaI detector shape. A wall thickness of 1/16 in. near the NaI crystal was a compromise between structural strength and minimizing γ-ray attenuation. The housing is sealed just behind the NaI crystal with dual sliding o-rings and fasteners. The small outer diameter allows deployment through narrow guide tubes into the area between the acrylic vessel and PMTs. The rounded cover above the mounting flange reduces the risk that the source will become lodged while being retracted from the guide tube. The hemisphere is the lowest point of the housing when deployed. Styrofoam molding will rest in the hemisphere to cushion the NaI detector. Mechanical testing of the housing will be completed in early 1999, followed by calibration activities later in the year.

Figure 1: ^{24}Na calibration source D_2O housing.